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Property Rights and Technology Transfer

Final Report

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D.G. McFetridge

and

D.A. Smith

Department of Economics

Carleton University

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The views presented in this paper are those of the authors and do not necessarily reflect the views or positions of the Department of C.C.A.

1. The Goals of the Study

The purpose of this study is to examine the relationship between the characteristics of the environment in which a technology transfer is to occur and the nature of the transfer which does occur.

A transfer can be made within a firm or between two firms. It can be made while the technology is new or postponed until it is older. It can involve rights to future improvements or be confined to the current state of the art.

The characteristics of the environment manifest themselves in the cost of transacting. The latter will be different for each technology and for each type of transaction. Government can, by operating on the law of contract and on the property right attached to technology, change the cost of technology transfer.

To understand the consequences of government policies which are intended to improve the terms upon which Canada obtains foreign technology, one must understand, first, how these policies will affect the cost of transfer and, second, how the cost of transfer affects the nature of the transfer. It is to these two tasks which this study is devoted.

2. The Coase-Williamson Theory of the Firm

The market and the firm provide alternative mechanisms for co-ordinating economic activity. This insight, due to Coase (1937) has not been extensively explored. One reason for this is its tautological nature. To say that transactions will be co-ordinated by the firm if the latter is the less costly co-ordinating mechanism is to explain everything and nothing. Contemporary applications of Coase's theory often do just that. The work of Buckley and Casson (1976) provides an example.

> "When markets in intermediate products are imperfect, there is an incentive to bypass them by creating internal markets. This involves bringing under common ownership and control the activities which are linked by the market" (1976, p. 33).

It is obvious that internalization involves the replacement of an imperfect market by a less imperfect firm. The important questions are: (i) what are the fundamental sources of the advantage of the firm over the market, given that both are imperfect? and; (ii) under what circumstances will these advantages manifest themselves? If the theory can be shown to imply a relationship between the characteristics of the environment within which an exchange occurs and the mode of exchange chosen, then a test of it is possible.

It is the purpose of this Section and of Section 3 to operationalize the theory of the firm, that is, to predict the circumstances under which transactions will be carried out within the firm rather than the market. We are assisted in this effort by

Williamson's (1975) pioneering examination of the issues raised by Coase.

Our discussion begins with the proposition that the cost of transacting can, under certain circumstances, be reduced if the obligations of the transacting parties are specified in detail as required rather than at the time the contract is made. The precise obligations of the transacting parties are determined in the context of the circumstances prevailing over the life of their agreement. This saves resources which would have been devoted to anticipating the circumstances which might prevail over the life of the agreement. It also saves resources which would have been required to specify the terms of the contract in anticipation of circumstances which do not ultimately prevail. Williamson labels a situation in which it is costly to anticipate and provide for events which may occur over the life of a transaction one of bounded rationality (1975, pp. 21-3).

The cost of transacting will, in general, be greater under conditions approaching bilateral monopoly. The disposition of the gains from trade will be the subject of a costly bargaining process. The net gain from trade is reduced, perhaps to the point at which no trade occurs. This situation is labelled by Williamson one of small numbers (1975, pp. 26-9).

The incidence of bilateral monopoly will be greater under conditions of bounded rationality. The reason is that, while we may assume that the pre-contractual situation is characterized by large numbers, this will not generally be true of the post-contractual situation. If the transacting parties make irreversible

commitments, subsequent attempts by either to turn to a competitor will involve a loss of quasi-rents. The post-contractual negotiation necessary to specify the details of the contract is then carried out under conditions which amount to bilateral monopoly.

The cost of transacting is also increased if either party has information relevant to the transaction which it is costly for the other to verify. The greater is the cost of verification the greater is the potential gap between supply and demand prices and the less likely it is that a transaction will occur. This situation is defined as one of information impactedness (1975, pp. 31-5).

The problem of information impactedness will be more severe under conditions of bounded rationality. Verification will be less costly in a pre-contractual situation because there are alternative buyers and sellers from whom information can be obtained. Post-contractual information impactedness involves the circumstances surrounding a transaction in progress. Third parties will be relatively less useful as sources of verification.

In sum, the cost of contracting can be reduced by conditioning the full specification of the contract on events as they occur. The extent of this reduction is, however, limited by the disproportionate incidence of small numbers and information impactedness on post-contractual negotiations.

The net advantage of sequential specification of the contract is greater the lower is the cost of post-contractual negotiation. Post-contractual negotiation is costly, in part, because both parties have an incentive to use it to improve their terms of trade. That is, each party will seek to have the detail of the contract specified to its own advantage.

One method of reducing the cost of post-contractual negotiation is to sever or at least attenuate its connection with the terms of trade. If the disposition of the gain from trade is determined at the outset, the incentive to use the process of post-contractual negotiation to change this disposition is reduced. While both information impactedness and small numbers may prevail, the incentive of each party to take advantage of the (private) opportunities they provide is reduced.

If the wealth of each party is to depend on the total gain from trade rather than on its disposition during the post-contractual period, there must be an initial pooling of interest. The terms on which pooling occurs will be the subject of costly pre-contractual negotiation. Once agreement is reached, however, the fraction of the gain from trade accruing to each party is determined. The process of post-contractual negotiation can not be used by one party to increase its wealth at the expense of the other.

It is this pooling of interest, this determination in advance of the disposition of the gains from trade which is, in our view, the essential characteristic of the firm. The alteration of the incentives brought about by the formation of the firm reduces the cost of sequential decision making. McKean puts this in the clearest terms.

> "Why is haggling less prevalent (it is by no means absent!) within an integrated firm than between independent components producers and a processor?

> Basically it is because the manager of an independent firm has a claim on part of that firm's profits, and lower level personnel in turn have claims on (i.e. they are rewarded for contributing to) that firm's profits. If these personnel work instead for the integrated firm, they are rewarded (more than before, at least) for increasing the integrated firm's profits" ...
>
> Because of this altered claim structure, it is now less rewarding to management of the components division to haggle with the management of the processing division (and vice versa). It is less rewarding than before to exchange dubious information or to engage in strategic bargaining." (1971, p. 124).

We note that this definition of the firm differs from both the Coase and the Williamson definitions. Coase defined the firm strictly in terms of sequential decision making.

> "... the service which is being provided is expressed in general terms, the exact details being left to a later date. All that is stated in the contract is the limits to what the persons supplying the commodity or service is expected to do. The details of what the supplier is expected to do is not stated in the contract but is decided later by the purchaser. When the direction of resources (within the limits of the contract) becomes dependent on the buyer in this way, the relationship which I term a firm may be obtained" (1952, p. 337).

Williamson endows the firm with a number of physical characteristics, low cost information flows, low cost monitoring and common experience which it can but need not have (1975, pp. 25-6, 29-30, 35-7).

In sum, the firm reduces the cost of sequential decision making. We expect to see the parties to a transaction form a - firm (internalize a transaction) when:

(a) the cost of transacting can be reduced by conditioning the detailed specification of the contract on the circumstances which prevail over its life and;

(b) when the requisite post-contractual negotiation must be carried out under conditions of small numbers and/or information impactedness.

From the standpoint of a single transaction there is a gain to internalization whenever bounded rationality and either information impactedness or small numbers prevail. Since most transactions will be carried out in such an environment, one might expect the bulk of exchange to be internal. That there remains a significant role for market transactions is obvious. There are limits to internalization.

The nature of the limits to internalization was anticipated, in part, by Coase (1952, p. 341). The pooling of interest in a single transaction requires a prior disposition of the surplus generated by that transaction. If the transacting parties are themselves engaged in a series of internal transactions, a pooling of interest is more costly to arrange. Each party's contribution to the pool must be evaluated. This implies an evaluation of the surplus on all internal transactions of both parties. The larger the number of other internal transactions, the more costly are the negotiations leading to a pooling of interest and the smaller is the net advantage to the internalization of a given transaction.

The limits to internalization are not, as Coase suggested, based on diminishing returns to co-ordination (1952, pp. 341-2).

If the internalization of an additional transaction yields no advantage it will be because the negotiation of the terms upon which it would occur is burdened with the evaluation of more than one transaction. The limit to firm size does not lie within the firm itself but in the size of the transactions it makes and the characteristics of the parties with whom it transacts.

3. Markets, Hierarchies and the Transfer of Technology

3.1 Introduction

In this Section we apply the Coase-Williamson theory of the firm to a particular set of transactions, those involving the transfer of new technologies. We describe the environment within which these transfers take place. We find that, for certain classes of transfers, the environment will be characterized by bounded rationality and post-contractual information impactedness and small numbers. This leads to the conclusion that, for these classes of transfer, there will be a net advantage to internalizing the transfer.

3.2 Bounded Rationality

3.2.1 Definition

The existence of bounded rationality implies simply that it is costly to the parties to a transaction to define the various states of nature which may prevail during the course of their arrangement and to specify their respective obligations in each of these states. Transaction costs can be reduced by specifying the obligations of the parties under a given set of circumstances as and when those circumstances occur. This practice can be labelled "sequential decision making" or "post-contractual negotiation."

The cost of negotiating the terms of a given exchange will be lower if the exchange occurs within a hierarchy. The reason is that the returns to the parties involved in an internal exchange

depend, to a large degree, on the gains from trade in total while the returns to the parties involved in a market exchange depend on both the gains from trade and their distribution. The costs of transacting in markets will, therefore, include the cost of efforts to influence the disposition of the gains from trade. These costs, while not necessarily zero, will be lower for exchanges conducted internally.

For two parties initially not linked by hierarchy and who wish to engage in trade, the choice between market and internal exchange depends on the existence of bounded rationality. In its absence there is no reason for the costs of negotiating the formation of a hierarchy to differ from the cost of negotiating a market transaction. Given bounded rationality hence the requirement for post-contractual negotiation the advantage of hierarchy emerges. While the cost of transacting will be the same in so far as pre-contractual arrangements are concerned, post-contractual arrangements can be concluded more efficiently within a hierarchy. The existence of bounded rationality is thus a necessary condition for the emergence of hierarchy.

3.2.2 The Incidence of Bounded Rationality

The extent to which parties to a transaction rely on post-contractual negotiations to identify which of the possible states of nature has prevailed and to specify their respective obligations depends on the cost of doing so in advance. The cost of allowing for each eventuality in advance, that is, of writing a complete contingent claims contract, will depend on: (a) the probability distribution of the contingencies; (b) the detail required to

distinguish among them and; (c) the extent to which the contingencies differ with respect to the obligations they imply for the parties to the transaction. Post-contractual negotiation hence an internal transaction is most likely to prevail where there are a large number of equally likely eventualities which must be described in detail if they are to be distinguished and where determination of the eventuality which has occurred is an important factor in the disposition of the gains from trade.

3.2.3 Bounded Rationality and Technology Transfer

Bounded rationality and thus reliance upon sequential decision making and upon hierarchy will be more prevalent among transactions involving technology. When compared transactions involving other goods and services, those involving technology will, on average, entail a greater range of possible outcomes the characteristics of which will be more costly to detail.

Within the category of technology transfer itself the range of potential outcomes will be greatest for new technologies and technologies involving significant advances on the state of the art. For technologies with which the parties involved have had little experience, the possible outcomes will be assigned equal probabilities (principle of equal ignorance).

Given the distribution of possible outcomes, it will be more costly to distinguish one from another and to assign obligations the more complex is the technology.

Given the characteristics of the technology, the number of possible outcomes will be greater the longer is the period over

which the transfer is to occur and the greater the number of end uses to which the technology may be put.

For purposes of measurement it might be supposed that the greater the number of years since its commercial introduction the older is a technology. Technologies developed by firms which devote a relatively large fraction of their resources to formal research and development might be supposed to be more complex. Because they are more likely to involve only supply side contingencies, transactions involving process technologies will, other things being equal, entail fewer possible outcomes than product technologies.

Given the technology, continuing transfer arrangements will involve more contingencies and these will be more costly to describe than will be the case with one-shot transfers. The reason is that the continuing transfer necessarily involves a longer time period and that little may be known of the characteristics of the technology ultimately to be transferred.

Similarly arrangements covering more geographic markets and more end uses (research versus production or single versus multiple product) will involve a greater number of outcomes.

Given the characteristics of the technology, then, arrangements involving a continuing transfer of technology as and when developed, to be exploited as and where the transferee wishes are most likely to necessitate reliance on post-contractual negotiation and thus on hierarchy.

3.3 Small Numbers

3.3.1 Definition

A small numbers situation is defined as one in which there is a small number of potential traders. The limiting case is that of bilateral monopoly. The fewer the potential traders the greater is the scope for bargaining and thus the greater is the cost of transacting.

In the technology transfer context, a small numbers situation will arise when the inventor of a technology faces a range of potential users, a few of whom can exploit the technology to greater effect than the others (including the inventor). The price at which the technology is ultimately transferred will lie between its value in the inventor's hands and its value in the hands of the efficient users. The negotiation of the division of the gains from trade between the inventor and those with the skills to exploit the invention is a potentially costly process.

The existence of costly bargaining is not itself sufficient to influence the choice between market and internal transactions. If an exchange is to be internalized the terms upon which internalization occurs remain the subject of a costly bargaining process. If there is no reliance on post-contractual negotiation small numbers increases the cost of market and internal exchange by the same amount. Given bounded rationality, however, small numbers does increase the advantage of internal over market transactions. Bounded rationality implies post-contractual negotiation. Small numbers implies that post-contractual negotiation will involve

costly bargaining. Internalization reduces if not eliminates the incentive to engage in post-contractual bargaining. The greater are the costs this bargaining involves, that is, the more severe is the small numbers problem, the greater is the advantage of internalization.

3.3.2 The Incidence of Small Numbers

A situation in which there are literally a small number of potential traders is unlikely to occur in the absence state restrictions to this effect. More likely is a situation in which there is a small number of relevant traders. Thus pre-contractual small numbers is most likely to occur where traders are heterogeneous. The credibility of the threat to trade elsewhere is limited by the reduction in the total gain from trade it is known to entail.

Post-contractual small numbers again involves the limited credibility of the threat to trade elsewhere. It occurs because the parties to the contract have made commitments which limit their ability to turn to alternative traders. To the extent that it has become costly to go elsewhere, a small numbers situation prevails.

Small numbers situations are likely to arise in transactions involving specialized resources or irreversible commitments.

3.3.3 Small Numbers and the Transfer of Technology

The small numbers problem is especially important in the transfer of technology. It has been argued [Cheung (1976)] that

those who would develop and expolit new technologies will be characterized by widely differing skills. The greater these skill differences the more likely is a pre-contractual small numbers problem.

Technology transfer is also more likely to involve post-contractual small numbers. Once the seller of the technology has fully revealed it to the buyer his probability of repossessing it, that is, of enjoining the buyer from the continued use of it, will be lower than the initial probability of preventing its use. Having obtained and operationalized the technology, the buyer may find that he can duplicate it without infringing any patents involved or that the expected cost of infringing or of defaulting on the terms of the transaction is relatively low. The seller's threat to go elsewhere will carry less weight in subsequent negotiations and a small numbers situation will have come into existence.

The scope for this type of opportunism on the part of the buyer will be greater the more is revealed during the course of the transfer. The newer is a technology and the greater is the advance it represents the greater is the buyer's post-contractual relative to his pre-contractual knowledge. For older more widely applied technologies, on the other hand, the transfer will do relatively less to change the bargaining positions of the buyer and seller.

-- There will also be situations in which the position of the seller is improved in post-contractual negotiations. This will occur if the commitment to a particular source of technology

involves specialization of the resources of the buyer. This situation may arise in a long-term continuing technology transfer arrangement. The fraction of the transferee's resources which are sunk will use over time and the seller may exploit this in negotiations over the transfer of the latest developments.

3.4 Information Impactedness

3.4.1 Definition

When one or more parties to an exchange possess information which is costly for others to verify a state of information impactedness is said to exist.

Information impactedness increases the number of contingencies with which the parties to an exchange must deal. Given bounded rationality this increases their reliance on post-contractual negotiation and thus the relative advantage of internal transactions.

Information impactedness also increases the cost of both pre- and post-contractual negotiation. Hierarchy reduces the effect of information impactedness on post-contractual negotiation. For a given set of contingencies, therefore, the advantage of internal over market transactions increases with the degree of information impactedness.

To elaborate, the inventor of a technology will have information regarding that technology which is relatively costly either for potential buyers or for competitors to verify. Being unable to verify the inventor's assertions, potential buyers will evaluate the technology on the basis of past experience. The owner of an

above average technology may expend resources signalling potential buyers that this is the case. Alternatively, he can offer to reimburse buyers in the event that his assertions are false and the technology they have acquired turns out to be a "lemon". The contract is amended to provide for an outcome which one party knows to be impossible. Information impactedness has the effect of adding to the number of eventualities for which the transacting parties must allow.

Information impactedness also increases the cost of determining which state of nature has prevailed. The buyer of a technology will be in a position to make assertions regarding its success which are costly either for the seller or for an outside arbiter to verify. If, for example, payment is contingent upon the profitability of the technology, the buyer may be able to assert that it has not been profitable and reduce if not escape payment. Since hierarchy has the effect of reducing the incentive to make such assertions, it also limits the effect of information impactedness on post-contractual negotiations.

3.4.2 Information Impactedness and Technology Transfer

The extent to which information regarding a good or service is impacted increases with the role of use, as opposed to prior inspection, in determining its value and with the extent to which its use has been concentrated in the hands of a few parties.

-- The characteristics of a technology will, in general, be relatively difficult to discern upon inspection. The more complex the technology and the greater the advance on the state of the art

it represents, the greater is the role played by use in determining its value. The newer the technology, the more limited its prior diffusion and the more distant its substitutes, the greater is the concentration of information in the hands of a few parties.

Although transfers involving technology will generally be burdened by information impactedness, the burden will fall relatively heavily upon the initial transfers of new and complex technologies. Transactions of this kind are more likely to be internal. Transfers in which the obligations of the parties vary markedly over the possible outcomes and in which the information as to which outcome has occurred is impacted are also more likely to be conducted internally.

3.5 Limitations on Internal Transactions

The essential characteristic of an internal transaction is that the wealth of the transacting parties depends only on the total gain from trade. Since the disposition of the gain from trade is determined at the outset, the parties to the transaction can subsequently improve their position only by increasing the total gain from trade.

The market transaction does not involve this initial pooling of interests. Throughout the life of the transaction the position of either party continues to depend on both the size and disposition of the gain from trade.

-- Given the reduction if not the absence of the incentive to further dispute the disposition of the gain from trade which it entails, the internal transaction will be characterized by simpler,

less costly post-contractual negotiations. In so far as an isolated exchange is concerned, the mere existence of bounded rationality is sufficient to insure the choice of the internal mode of transacting.

The source of the advantage of the internal transaction, prior disposition of the gain from trade, is also the source of its limitations. Consider a transaction between two hierarchies. By definition, these hierarchies each involve a set of internal transactions, the gains from which are shared in a predetermined manner. If there is to be an internal transaction between the hierarchies there must be a pooling of interest and a disposition of shares. This involves the negotiation of the claim to the aggregate surplus to which each member of both hierarchies is entitled whether or not that member is directly involved in the transaction in question.

In the case of a market exchange there is no initial pooling of interest. There is no need to renegotiate the claims of the members of either hierarchy in the light of the additional transaction.

The cost of renegotiating the disposition of the entire surplus is a lump sum addition to the cost of an additional internal transaction. The smaller is the proportion of total surplus due to this transaction the larger is this "overhead" component of its cost. The cost of transacting internally is an increasing function of the number of otherwise unrelated transactions which must simultaneously be internalized.

Suppose, for example, there is to be a transfer of technology between firms A and B which are themselves engaged in internal transactions with C and D respectively. The terms upon which an internal transfer between A and B occurs necessarily reflect an evaluation and a disposition of the surplus on existing A-C and B-D transactions. The terms upon which merger between A-C and B-D occurs reflect more than the terms of the A-B technology transfer.

In general, then, the smaller is the value of the transaction in relation to the existing internal transactions of each party and the less closely related are these other internal transactions, the greater is the probability that, other things being equal, the market mode will be adopted.

4. Transaction Costs and Licensing Practices

4.1 Introduction

The provisions of technology transfer agreements are generally analyzed in the context of their effect on the disposition of the gains from trade. Relatively little attention has been paid to the effect of these same provisions on the cost of transacting. The purpose of this section is to examine the effect of a number of common licensing practices on the cost of transacting in markets.

4.2 Bounded Rationality

It has been argued that the greater the number of contingencies with which the parties to a transaction must deal, the greater is the relative disadvantage of a market transaction. One way of reducing the number of contingencies is to reduce the number of situations to which an agreement applies. This may be accomplished by specifically limiting the time period, the number of geographic markets and the number of product markets and/or end uses to which a technology transfer agreement applies.

A potential licensee with an interest in a specific market, Canada for example, can reduce the number of contingent arrangements which must be negotiated simply by renouncing any intention to sell in other markets. A potential licensee whose interest is confined to the production as opposed to the research uses of a technology can eliminate negotiations regarding the latter by offering a unilateral grantback of derivative technologies.

4.3 Small Numbers

Given bounded rationality, the existence of either pre- or post-contractual small numbers will increase the relative cost of market transactions. Post contractual small numbers can be avoided, in part, by a policy of non-exclusive licensing. Given the number of licensees, however, the licensor is vulnerable to post-contractual attempts to change the terms of trade (opportunism) in that the replacement of one group of licensees by another is costly even if the licensor has a legal right to do so. Once a technology has been fully revealed, the cost of enjoining a licensee from its further use in the event of a violation of the agreement may be sufficient to deter an attempt by the licensor to do so. In the sense that the original transaction has created a group with whom the licensor must deal, a small numbers situation has arisen.

The incentive of a licensee to exploit this type of situation can be reduced by allowing him what appears from a pre-contractual standpoint to be a generous share of the rents to a new technology. Over the course of the license arrangement this may be just sufficient to make attempts to further alter the terms of trade unattractive. The standard rule of thumb that the licensee and licensor should share in the rents in a three to one ratio indicates that licensors generally pay a rather large premium to avoid licensee opportunism (Wilson (1975) p. 24). While payment of this premium will be preferable to incurring the cost of post-contractual disputes, it is clearly inferior to the internalization of the

exchange and the consequent elimination of the small numbers problem itself.

License agreements may also contain clauses designed to eliminate some of the more obvious forms of opportunism. One example is a no-challenge clause (licensee estoppel) under which a licensee agrees not to challenge the patent under which he is being licensed. This allows a potential licensee to warrant that he is not licensing simply to obtain enough information to invalidate the patent. This obviously increases the relative attractiveness of licensing (the market transfer).

Another license provision designed to limit licensee opportunism is the "best efforts" or "tie out" clause under which a potential licensee warrants that he is not licensing in order to suppress a technology in favour of some substitute in which he may also have an interest.

4.4 Information Impactedness

Licensing practices which reduce the effect of information impactedness include the use of running royalties and the awarding of non-exclusive licenses.

The running royalty provides a means of payment which is conditional on the success of the technology. This is a superior form of transacting for the inventor who knows that his technology is not a "lemon" but can not demonstrate this to potential buyers.

-- Information regarding the success of the technology will, however, be impacted in the hands of its users (licensees). The licensor can reduce the extent of post-contractual impactedness

by awarding non-exclusive licenses and by defining relevant contingencies in terms of variables that are readily observable.

The greater the number of licensees the less scope there is for opportunistic assertions regarding the success of the technology. Similarly, while royalties based on profits are ideal in the sense of reflecting the success of the technology and of providing the appropriate marginal incentive, licensee assertions regarding profits will be costly for the licensor or an outside arbiter to verify.

More readily observable are licensee sales, output or inputs. While sales, output and input royalties (tying arrangements) do not provide the licensee with the incentive to maximize the value of the technology, they will reduce the cost of post-contractual negotiation. In this case license provisions are chosen so as to minimize the cost of transacting subject to incentive effects.

5. Empirical Evidence on the Cost of Technology Transfer

5.1 Introduction

In the sections which follow we summarize the evidence on the cost of technology transfer and on the factors which determine the relative costs of market and internal transfer. The evidence is interpreted within the context of the theory of the choice of modes of exchange advanced in Sections 2 and 3.

A discussion of the evidence on the cost of internal transfer appears in Section 5.2. This is followed by an examination of the characteristics of market transfers. Here inferences are drawn from technology transfer agreements.

Section 5.4 summarizes and evaluates the evidence on the determinants of the choice between market and internal transfer. This includes studies of the circumstances under which each of joint ventures, licensing agreements and foreign direct investment is the preferred mode of technology transfer.

5.2 Evidence on the Cost of Technology Transfer by Hierarchy

The evidence on hierarchical transfer of technology is largely based on the study of technology transfer within multinationals. Much of the evidence is anecdotal. It was not assembled with a view to hypothesis testing and it would be only by accident that it would prove useful for that purpose. Examples of this type of evidence are provided by Behrman and Wallender (1976), Ronstadt (1977) and Baranson (1978).

There have been some attempts at systematic analysis. Some have proved unsuccessful (Jeannet and Liander (1978)). Teece (1976) meets with somewhat more success. A discussion of his findings occupies the balance of this section.

Teece studied twenty-nine technology transfers occurring over the period 1960-1975. Of these fifteen were strictly internal, eight were joint ventures, four were market (to independent enterprises) and three were to independent government enterprises. The transfers involved are horizontal transfers of a capability to manufacture or to use a process. The term horizontal is meant to imply that this is simply another application of a previously commercialized technology, not a stage in the development of it.

Technology transfer costs are defined as

> ...the costs of transmitting and absorbing the relevant firm-, system- and industry-specific knowledge to the extent that it is necessary for the effective transfer of the technology. The costs of performing the various activities that have to be conducted to ensure the transfer of this information will represent the cost of technology transfer. (p. 36)

The activities required include: (a) pre-engineering technological exchanges in which theoretical insights and the characteristics of the technology are revealed; (b) engineering specification and design transfers; (c) R & D costs incurred adapting or modifying the technology for purposes of transfer and dealing with new technical problems raised by the transfer; and (d) pre-start up-training costs and excess costs of early production.

Teece finds that transfer costs, as defined, account, on average, for some twenty per cent of total project cost (p. 45).

Excess manufacturing and training costs account for approximately half of the total transfer cost (p. 45). This is evidence that even "one-shot" transfers take time to effect and that during that time circumstances change in unforeseen ways. The largest component of transfer costs is incurred subsequent to the transfer itself.

It would also have been of interest to know the distribution of R & D costs associated with the transfer. These again represent costs of adapting to changes in circumstances, not all of which will have been foreseen and which militate in favor of hierarchical transfers.

Teece found that, in general, transfer cost as a fraction of project cost was: (a) a decreasing function of the number of firms using the technology; (b) a decreasing function of the age of the technology; (c) a decreasing function of the number of previous startups; (d) a decreasing function of the number of years manufacturing experience of the transferee.

With the exception of the number of firms using the technology which is always significant, the influence of his independent variables depend on the specification employed. The relations cited in the preceding paragraph are at least occasionally significant (p. 60).

These findings confirm our expectation that the cost of transacting, whether internally or via the market, decreases as the technology to be transferred becomes more widely known and understood.

The second, and more important proposition we advanced was that the decline in the cost of a market transaction will be

proportionately greater than the cost of an internal transaction. Teece attempts to address this issue but does so incorrectly. He tests the hypothesis that, other things (age, number of prior start-ups, number of firms using the technology) being equal, the cost of a market transfer differs systematically from the cost of an internal transfer. Specifically, he expects that, given the characteristics of the transfer, the cost of a market transfer will exceed that of an internal transfer. He finds that there is no difference (p. 59).

Teece's finding should not come as a surprise. If, for any given set of characteristics, the cost of the market transfer exceeds that of the internal transfer, the former will never be chosen. The correct approach is to test the hypothesis that the marginal influence of age, prior start-ups, number of firms using the technology etc., is greater in the case of the market transfer. In the simplest terms, Teece ought to have allowed slope coefficients to differ between these two classes. We conjecture that were he to do so, Teece would find that although the cost of market exchange is higher at the outset (larger positive intercept), it falls more quickly with age etc. (larger negative slope).

Teece was confined to testing for shifts in the intercept by the fact that his sample included only four observations on transfers to non-affiliates. He could, however, have followed Stopford and Wells (1972) in comparing the characteristics of technologies transferred internally with those transferred to joint ventures. -

Teece does conduct another test which is relevant to the analysis of relative transfer costs. He asks each of the

transferors how much more it would have cost had their transfer been arm's length (market) in nature. This gives a biased estimate of the mean cost difference because the least those who chose the market route can say is zero. Even so, the mean percentage by which the cost of market exceeds the cost of internal transfers does not differ significantly from zero (p. 82).

It is the subsequent analysis of the determinants of inter-transfer differences in the excess of the cost of market over internal exchange which yields an important insight. Teece finds (p. 84) that this excess is significantly greater for transfers of technology for which there has been no prior commercialization. The disadvantage of market exchange lies, as expected, where the technology involved is virtually an unknown quantity.

5.3 License Based Evidence

Licensing data provide two types of evidence on the determinants of the relative costs of market and internal technology transfers. First, to the extent that internal transfers involve some kind of license agreement, a comparison of license agreements between affiliates with agreements between unaffiliated firms amounts to a comparison of internal and market transactions.

Second, a systematic tendency for license agreements, designed to facilitate a given type of technology transfer, to include a particular set of provisions can be viewed as an attempt to minimize the cost of market transfers. This provides some rough evidence as to which facets of a transfer are costly and which provisions of the agreements have a significant cost reducing effect.

If an aggregate comparison of inter-affiliate with arm's length license agreements is to be informative it must be the case that inter-affiliate licenses are representative of internal transactions. The evidence is that most internal transfers do involve license agreements and that the proportion of internal transfers involving licenses has increased since this evidence was assembled (Lovell (1969) p. 14).

A comparison which, in a very rough sense, can be viewed as between inter-affiliate and arm's length transfers has been conducted by Killing (1975). The latter is able to compare the characteristics of the agreements entered into by two groups of licensees, Canadian resident and owned firms and Canadian resident but foreign owned firms. Half the licensing activity of the second group is with affiliates (p. 11). Inferences regarding differences between internal and market transactions which are drawn from a comparison of these two groups of licensees are based on the heroic assumption that it is the presence of inter-affiliate transfers in the second group which leads to the differences which are observed.

Examining 462 agreements between Canadian controlled licensees and foreign licensors and 1,469 agreements between foreign controlled licensees and foreign licensors (695 of which were inter-affiliate licenses), Killing found an average payment of $12,568 per license among the Canadian controlled licensees and $52,537 among U.S. controlled licensees (p. 11). The smaller payment per license made by Canadian licensees reflects some combination of lower sales per license and lower royalty rates. Given the caveats

stated above, the observation of lower sales per license is consistent with the expectation that, other things being equal, the market transaction will involve a smaller share of the activity of the transacting parties. The observation of a lower royalty rates is consistent with the expectation that market transactions will involve technology which is older and simpler than will internal transactions.

A similar conclusion can be drawn from Killing's finding that sales made under license comprise a smaller fraction of the total sales of "medium and large" Canadian controlled licensees (his own sample) than is the case for the population of licensees as a whole (p. 112). Given the large fraction of the population accounted for by foreign owned licensees, and the importance of inter-affiliate transfers within that group, it is not unreasonable to infer that technology transferred via the market accounts for a smaller share of the activity of the transferee than technology transferred internally.

Killing also finds that, although Canadian controlled licensees make lower payments per license their mandatory purchases per license were significantly higher than those of foreign controlled licensees. To the extent that the license arrangements of these two groups can be said to represent market and internal transactions respectively, this result is consistent with the expectation that, because information regarding the success of the technology is impacted, the market transaction is more likely to make use of low cost metering devices. Payment based on tied purchases fulfills this requirement.

Killing classifies his own sample of licenses according to whether they involve one-shot or continuing transfers of technology. Because it entails a greater number of outcomes and thus involves a greater amount of post-contractual negotiation the continuing technology transfer is more likely to be conducted internally. Continuing transfers conducted via the market will also differ from one-shot transfers conducted via the market. Because they entail a greater number of eventualities requiring post-contractual negotiation, continuing technology transfers offer a larger return to measures which reduce the cost of these negotiations. Similarly, if continuing technology transfers were to involve more costly post-contractual negotiations (due to small numbers or information impactedness) they would offer greater returns to provisions restricting the number of potential outcomes.

One of Killing's first observations is illustrative. He finds that initial expenditures on physical capital by the licensee is greater in the case of one shot transfers than in the case of continuing transfers (p. 119). The continuing transfer entails continuing or post-contractual negotiation. The greater is the physical commitment of the licensee to the licensor, the greater is the cost, to the former, of going elsewhere and the more his situation resembles one of small numbers (Section 3.3.3). The greater the reliance on post-contractual negotiation, the greater is the gain from avoiding a small numbers situation and thus from minimizing the extent of licensee specialization.

A second observation is that continuing technology transfers are more likely to involve products in the later phases of their

of their life cycle than are one shot transfers (p. 121). That is, continuing transfer arrangements are more likely to involve an older technology. The older the technology the fewer the contingencies and the less costly they will be to distinguish (Section 3.2.3). The gain from reducing the number of contingencies is greater the more costly the negotiations they involve, that is, in the case of the continuing technology transfer.

A third finding is that one shot technology transfers occur, on average, under conditions of greater technical uncertainty than do continuing transfers (p. 117). The arguments given above lead to the conclusion that the effect of technical uncertainty is proportionately greater in the case of the continuing transfer. The gain from replacing a market with an internal transaction or from waiting until technical uncertainty is reduced is greater in the case of the continuing transfer.

A fourth observation tends to confirm and, to a certain extent, restate the previous two. One shot transfers involved an average lag of from 6 to 8 years between first world introduction while continuing transfers involved a lag of 16 years. Again the marginal reduction in transaction cost achieved by waiting and transacting in an older technology is greater in the case of a continuing transfer.

A fifth finding is that export restrictions are more prevalent in the case of continuing transfers than in one shot transfers (p. 128). The renunciation of export markets simply reduces the number of contingent arrangements to be negotiated. The gain from doing so is greater in the case of the continuing transfer agreement.

In sum, it has been argued that the continuing technology transfer is characterized by a greater range of possible outcomes and a higher cost of establishing both the outcome which has prevailed and the obligations of the transacting parties. This implies a greater return to measures which reduce either the number of outcomes (export restrictions, older less uncertain technology) or the cost of defining and responding to any particular outcome (minimization of sunk cost, use of an older less uncertain technology).

5.4 Evidence on the Determinants of the Relative Importance of Markets and Hierarchies in Technology Transfer

5.4.1 Introduction

Systematic evidence regarding the circumstances under which market and internal transfers of technology occur is only beginning to appear. The results of several major studies are summarized in the sections which follow.

There have also been studies which touched but did not concentrate on this issue. These include Caves (1971) and Stobaugh (1974).

Caves concluded that internalization will be chosen when

> "either the information cannot be transferred independently of the entrepreneurial manpower, or uncertainty about the value of the knowledge in the foreign market will preclude agreement on the terms of a licensing agreement that will capture the full expected value of the surplus available to the licensor" (1971, p. 7).

Caves' position is similar in some respects to that which is taken here. The internal transfer is chosen because it involves a greater gain from trade net of transactions cost. Information

impactedness reduces the net gain from trade but reduces the net gain from market exchange proportionately more.

Caves also argues that

> "...the relatively high fixed costs of securing the information necessary to undertake a foreign investment predispose the small firm to settle for licensing" (1971, p. 7).

Our position is that all exchange involves costs which do not vary with the size of the transaction but that the fixed costs of an internal transaction will be greater relative to the fixed costs of a market transaction the smaller is the fraction of the activity of the transacting parties accounted for by the transaction. The level of fixed costs will determine whether a transaction occurs. The size of the transaction relative to that of the parties to it determines whether it will be internalized. In no case is the size of the owner of the technology relevant.

Stobaugh argues that, given the choice, owners of technology will prefer an internal transfer because

> "...greater monopoly profit might be obtained by combining all the factors needed for a foreign operation, rather than selling just one factor, such as production knowhow ... [and] ... the parent has greater freedom to co-ordinate the operations of a wholly owned subsidiary with the rest of its operations than it does with a joint venture or licensee". (1974, p. 20).

Licensing occurs, in Stobaugh's view, only when the owner of the technology has no choice.

> "When a product is mature the technology is available to many more firms; so a firm preferring to invest may not have the investment alternative and might be forced to license to obtain some income rather than no income from its technology". (1974, p. 20).

In our view the option of internal transfer exists regardless of the number of substitutes a technology might have. The mature, well-known technology will be licensed, not because its owner has no choice, but because its transfer has become relatively simple. The possibility of post-contractual disputes for which internalization is the remedy diminishes with the maturation of the technology.

5.4.2 Evidence from Joint Ventures

The joint venture lies between an internal and a market exchange. It economizes on the cost of internalization by limiting the extent to which interests are pooled. The cost of pooling interests which are essentially unaffected by the transaction are eliminated.

Because a full pooling of interests has not occurred the joint venture will be subject to the same type of costs experienced by those engaged in market exchange. Given bounded rationality the costs of post-contractual negotiation will lie between those of an internal transaction and a market transaction.

We would expect to observe joint ventures, first, where the costs of a complete pooling of interest were relatively high. This would be true of transactions which accounted for a relatively small fraction of the activity of both parties.

Second, given the costs of effecting a complete pooling of interest, joint ventures are more likely the greater is the advantage to a partial pooling of interest. The advantage of any pooling of interest, that is, a marginal retreat from market

exchange, is greater the greater the extent of bounded rationality. Given bounded rationality, small numbers and information impactedness increase the return to a movement away from market exchange.

The evidence on joint ventures comes, first, from Stopford and Wells (1972). These authors examine the choice among full internalization, majority and minority joint ventures. They find, first, that the fraction of subsidiaries which are wholly owned increases with the R & D intensity of the enterprise and, conversely, that the fraction of subsidiaries which are minority joint ventures decreases as R & D intensity increases (p. 120). These findings are detailed in Table 5.1.

Second, employing multivariate analysis the authors find that the fraction of subsidiaries accounted for by minority joint ventures is a decreasing function of a firm's advertising and R & D intensity and an increasing function of the extent of its diversification (Tables C-4, C-6).

This evidence is limited in the sense that transfers which involve an arm's-length (market) relationship are not included. Within the restricted set of transfers considered, this evidence is consistent, first, with the proposition that reliance on full internalization (100% ownership) is greater the more complex is the activity, that is, the greater is the R & D intensity of the parent. Second, the more diversified is the parent the greater is the overhead burden attached to the internalization of a given transaction and the more likely is a contractual form which stops short of full internalization.

TABLE 5.1

Type of Subsidiary and R & D Intensity

Type of Subsidiary	R & D Intensity (R/S)			
	< 1.1%	1.1% < R/S < 3%	3% < R/S < 5%	R/S > 5%
100% ownership	56%	67%	72%	78%
majority joint venture	20%	11%	11%	10%
minority joint venture	24%	22%	17%	12%
Total	100%	100%	100%	100%

Source: Stopford and Wells (1972, Figure 8-2).

A second source of evidence on joint-ventures is provided by Stobaugh (1971). The latter finds that the probability of 100% control as opposed to joint venturing in the petrochemical industry is greater: (a) the larger is the firm involved; (b) when the firm involved was the source of the technology for the venture; (c) the less developed is the country in which the facility is located; (d) when the firm involved is an oil rather than a petrochemical company and (e) the later is the product in its life cycle.

Relevant here are three findings. First, it is the transfer of technology as opposed to other, presumably less complex, assets which results in full internalization. Second, the more distant is the parent's principal line of business (oil from petrochemicals) the less likely is full internalization. Third, the later is the stage in the product life cycle the more likely is full internalization.

The third finding contradicts the central thesis of this study, to wit, the likelihood of a market transaction increases with the age of the technology to be transferred. Other information indicates, however, that the fraction of transfers which are by license rather than partially or fully internal does increase with the age of the technology. While not helpful, Stobaugh's finding is not fatal to our thesis.

A final source of information on joint ventures is provided by Berg and Friedman (1978). The latter calculate the incidence of joint venture activity and of technological joint ventures in twenty United States industries over the period 1964-75. While the propensity to joint venture reveals relatively little in the

absence of information on the total number of transfers, internal and market, involved, the Berg and Friedman data (reproduced in Table 5.2) do provide some insights. In particular, the most technologically complex industries (in terms of R & D intensity) are not among those which rely relatively heavily on technological joint ventures. The top five industries in terms of R & D intensity ranked seventh, thirteenth, ninth, fourth and eighth respectively in terms of technological joint venture participations per firm. Similarly, industries which are not research intensive place relatively little reliance on technological joint ventures. This outcome is consistent with the proposition that, other things being equal, the most complex technologies will be transferred internally and the least complex will be transferred by license. The partial internalization which a joint venture entails occurs when the technology to be transferred lies somewhere in between. Whether this conclusion could withstand a more rigorous multivariate scrutiny of these data is a matter of conjecture.

5.4.3 Stobaugh (1971)

Stobaugh studied the international diffusion of nine petrochemical technologies. He finds that the fraction of transfers of these technologies which occurred via license increased significantly in the later stages of their life cycle. Given the definition of the life cycle, this implies that the fraction of transfers via license increase as a technology becomes older, more widely used and there are more competing technologies. Stobaugh's findings are summarized in Table 5.3 below.

TABLE 5.2

Joint Ventures: By Type and
By Industry, U.S. 1964-75

Industry	J.V. Incidence	Technological J.V. Incidence	R/S(%)
Metal Mining	.910	.202	.
Petroleum and Gas	.447	.078	.
Food	.383	.208	.4
Textiles	.082	.041	.4
Basic Chemicals	1.430	.755	3.6
Ethical Drugs	.343	.252	7.5
Paint, Agricultural Chemicals	.288	.144	1.8
Petroleum Refining	2.614	.797	.6
Glass and Non-Metal Containers	.648	.449	1.5 }
Cement, Clay, Gypsum	.311	.106	1.5 }
Iron and Steel	.546	.130	.5
Nonferrous Metals	1.063	.364	1.2
Metal Containers	.279	.131	1.2
Nonelectrical Machinery - General	.349	.220	4.1 {
Nonelectrical Machinery - Specialty	.091	.076	4.1 {
Electrical Machinery	.518	.383	6.7
Electronics and Computers	.194	.141	10.9
Autos and Auto Parts	.473	.370	3.5
Aircraft and Transportation Equipment	.417	.303	12.2
Scientific Instruments	.315	.263	5.3

Source: Berg and Friedman (1978), Table 1.7, NSF (1976), Table B-36

Note: J.V. Incidence = J.V. participations per firm.

TABLE 5.3

Forms of Technology Transfer for Plants Manufacturing Nine Representative Petrochemicals

Stage of Product Life Cycle	Ownership (proportion)	Licensing (proportion)
I (New)	73%	27%
II	41%	59%
III (Mature)	27%	73%

Source: Stobaugh (1971, p. 29)

Stobaugh ascribes his findings to monopoly power. Firms without it will have to license their technologies. The older is the technology the weaker is the monopoly and the greater is the likelihood that the owner of the technology will "have to accept a license."

Although the existence of monopoly is not irrelevant to the choice between market and internal transfer, there are other, more important, factors at work here. A firm does not forego its monopoly when it chooses to license. We have argued, however, that the newer and less widely used is a technology the greater is the relative cost of market transfer and the smaller will be the net return under licensing. It is the dispersion of an experience with a technology and the appearance of substitutes for it which reduce both the gains from relying on sequential decision making and the relative disadvantage of market arrangements which do so.

5.4.4 Wilson (1975)

Wilson estimates royalty payments for technology for each U.S. two digit manufacturing industry. These royalty estimates, taken together with reported R & D expenditures, provide some indication of the importance of licensed as opposed to internally generated technology. Since estimated license payments include royalties paid to affiliates, the ratio of license payments to R & D expenditures does not necessarily reflect the relative importance of market and internal sources of technology.

While Wilson does attempt to specify a model of the determinants of inter-industry differences in license payments, the

specification can be improved upon if the arguments advanced in Section 3 are taken into account. Consider an industry composed of n firms each of which conducts annual R & D in the amount of \$R and licenses it to the other members of the industry. Total license receipts are such as to cover the pro-rated share of all other firms in each firm's R & D costs. Then the annual license payment of the i^{th} firm to the j^{th} is

$$L_i = (1/n)R_j \qquad 5.4.4.1$$

The annual license payments of all n-1 firms to the j^{th} is

$$\sum_{i=1}^{n-1} L_{ij} = [n/(n-1)]R_j \qquad 5.4.4.2$$

The annual license payment of all n firms to the (n-1) other firms in the industry from which technology is obtained is

$$\sum_{j=1}^{n} \sum_{i=1}^{n-1} L_{ij} = [n/(n-1)]\Sigma R_j \qquad 5.4.4.3$$

Since the industry is assumed, at this point, to be closed, $\Sigma\Sigma L_{ij}$ represents industry aggregate license payments and ΣR_j represents industry R & D expenditures. If the firms are of equal size the Herfindahl index, H, is equal to 1/n. If the firms are of unequal size H continues to represent a numbers equivalent of the distribution of market shares. In this case license payments made by the k^{th} industry can be written as

$$L_k = (1-H_k)R_k \qquad 5.4.4.4$$

Now some of the technology used by the $k^{\underline{th}}$ industry will be purchased from sources outside the industry. Royalties in the amount T_k must be paid annually for this technology. Total annual license payments made by the $k^{\underline{th}}$ industry are then

$$L_k = (1-H_k)R_k + T_k \qquad 5.4.4.5$$

This expression will hold as an identity under the assumptions made to this point. It can, however, be expressed as a behavioral equation and used to test two propositions. First, as the number of producers increases (H falls), license payments should rise relative to R & D expenditures. Second, since the more complex the technology the less likely it is to be transferred by license agreement, the ratio of license payments to R & D expenditures will be smaller the more R & D intensive (technologically complex) is the industry. Annual license payments can then be expressed as

$$(L/R)_k = b_0 + b_1(1/R)_k + b_2H_k + b_3(R/S)_k + u_k \qquad 5.4.4.6$$

where $b_0 > 0$, $b_1 > 0$, $b_2 < 0$, $b_3 < 0$.

The coefficient b_1 is an estimate of T, the average royalty payment for technology developed outside the industry. The model also implies that the ratio of license payments to R & D expenditures decreases as R & D expenditures increase and as market concentration increases.

The ratio of license payments to R & D expenditures implied by Wilson's data together with industry R & D : Sales ratios are reported in Table 5.4. These data allow an initial naive assessment

TABLE 5.4

Royalty Payments/R & D Expenditures U.S. 1971

Industry	L/R[1]	R/S[2]
Food and Tobacco	.134	.005
Textiles and Apparel	.436	.005
Paper	.070	.008
Industrial Chemical	.089	.039
Drugs	.185	.075
Other Chemical	.056	.019
Petroleum	.073	.009
Rubber	.087	.018
Stone, Clay, Glass	.116	.017
Ferrous Metals	.127	.007
Non-ferrous Metals	.062	.010
Fabricated Metals	.172	.011
Machinery	.023	.039
Electronics	.039	.083
Other Electrical	.037	.064
Motor Vehicle and Other Transportation	.007	.031
Aircraft	.022	.159
Instruments	.057	.056
Other Manufacturing	.209	.008

1. Source, Wilson (1975, p. 118).
2. Source, National Science Foundation (1976) p. 59.

of the hypotheses advanced above. It appears that L/R bears a strong negative relationship to R/S. This occurs for two reasons. First, license payments made to suppliers of technology outside the industry will, be definition, fall relative to R & D expenditures as the latter increases. Second, greater R & D intensity implies greater technical complexity which, in turn, implies relatively less licensing activity.

Wilson's own estimates tend to confirm our expectations regarding the effect of market concentration on the ratio of license payments to R & D expenditures. He finds that given both the scale of the industry and the degree of technical complexity (his own measure), the greater is market concentration the lower are license payments (p. 138).

5.4.5 Telesio (1977)

Telesio examined interfirm differences in the ratio of foreign licensee sales to total sales of licensees and foreign affiliates for thirty-three multinationals in 1974. He found that this ratio was an increasing function of the R & D intensity of the multinational, a decreasing function of its size relative to the largest in its industry, an increasing function of its level of product diversification and an increasing function of the fraction of sales manufactured abroad (Table VI.1).

These findings provide some support for the hypotheses advanced in Section 3. The positive relationship between the extent of licensing and diversification is reflective of the relatively high overhead cost of internalizing the other transactions of the diversified firm.

Two other findings are inconsistent with the predictions made in Section 3. One expects the importance of licensing relative to internal transfer to decrease as R & D intensity (product complexity) increases. Telesio concludes that the reverse is true. The problem here is that Telesio has not isolated the effect of R & D intensity on the mode of technology transfer. He is examining sales under license relative to total foreign sales. Since licenses are generally used to transfer either trademarks or technology, it is not surprising that there exists a positive relationship between the fraction of foreign sales under license and R & D intensity. This does not imply that, among technology transfers per se, the more R & D intensive technologies are not more likely to be transferred internally.

Telesio also finds that the greater is the fraction of foreign activity the greater is the relative importance of licensing. Our expectations were that the reverse would be true. The greater the extent of foreign activity the greater is the advantage of internalization. Again there is the problem of separating the scale from the substitution effect. Greater aggregate foreign activity will be associated with a greater volume of technology transfers some of which will be via license. The decision to internalize a particular technology transfer will still depend on the size of the transaction and of anticipated future transactions. As these increase the relative cost of the internal transfer decreases. To the extent that expectations regarding the volume of future transfers are conditioned on the past, one expects that the greater the volume of prior transfers the higher is the probability

that a given transfer will be internalized.

Telesio makes two other discoveries which have a bearing on the hypotheses advanced in Section 3. He finds, first, that diversified firms are significantly more "willing" to license technology which: (a) is already subject to competition; (b) can be duplicated and; (c) has been superceded (Table VI-13). It is this type of technology for which the specification of contingencies is less costly and for which information impactedness and post-contractual small numbers will be less important. For this reason both the gain from sequential decision making and the relative disadvantage of market arrangements designed to facilitate it will be smaller.

Second, Telesio finds that, among diversified firms, there is a greater willingness to license "secondary" lines. The latter will, by definition, comprise a relatively small fraction of the activity of one transacting party and, possibly, of the other. The greater is the value of this other activity relative to the transaction in question, the greater is the relative cost of internalization. The relative cost of internalizing the transfer of a secondary product line will, other things being equal, exceed the relative cost of internalizing a primary product line.

5.4.6 Davidson (1979)

Davidson examines the characteristics of 580 new product transfers undertaken by U.S. based multinationals over the period 1946-75. In particular he attempts to distinguish the characteristics of new products transferred to wholly owned affiliates from

those of new products transferred to independent licensees. This parallels the attempt made in this study to distinguish between internal and market transfers.

Davidson finds that a country will receive a given U.S. technology earlier the larger is the market it represents, that is, the greater is its GNP (p. 41). Moreover, the earlier a country receives a technology the more likely it is to receive it through internal transfer (p. 84). These findings are consistent with the view expressed here, that relative factor costs, and market size will determine the age at which a technology is transferred to a given country and the age of the technology will determine the mode of transfer. The older is the technology the more likely it is that the market mode will be employed.

It was argued in Section 3.5 that the internalization of a transaction involves costs which must be viewed as a lump sum charge to that transaction. If this overhead can ultimately be spread over other transactions, the cost of internal relative to market transfer is reduced. The greater the number of transfers the owner of a technology expects to make to a given party (country) the more likely it is that the initial transfer will be internalized.

Davidson's results are partially supportive of this line of reasoning. He finds that a transfer is more likely to be internalized: (a) the larger is the total number of prior transfers in which its owner has participated; (b) the larger is the number of prior transfers made by its owner to the country in question and; (c) the larger is the number of prior transfers made by its owner

within the same industry (p. 87). Provided the number of prior transfers, both of a general and of a specific kind, serves as a basis upon which expectations of future transfer activity are formed, these findings support the hypothesis.

Davidson also finds that a transfer is more likely to be internalized the larger is the number of prior transfers of that particular technology (p. 87). The expectation that there will be many transfers of a particular transfer does nothing to reduce the overhead associated with internalizing a given transfer of it. Indeed, one might expect that the more often a technology is transferred the less is the reliance on sequential decision making and the lower is the relative cost of a market transfer. Davidson's finding does not support this line of reasoning.

Once a transaction has been internalized and the associated overhead cost incurred, it is the marginal cost of the internal transfer which is relevant to future choices regarding the mode of transfer. Given the existence of an affiliate, therefore, the greater is the likelihood that transfers to the country in which the affiliate resides will be internal, that is, to the affiliate. Davidson finds that this is indeed the case. The use of licensees is significantly lower in countries where the transferor already has an affiliate (p. 80).

It was argued in Section 3 that the smaller is the value of a transaction relative to the total activity of the transacting parties and the more distantly related are their other activities, the greater is the overhead charge which will burden the internalization of the transaction.

This argument receives some support from Davidson's findings. He finds, first, that technologies outside of their developer's principal industry are more likely to be transferred via license (p. 100). Second, regardless of the characteristics of a technology, the more diversified is its transferor the greater is the likelihood that the transfer will occur via licence (p. 101). This is due, first, to the overhead cost of internalizing an already diverse set of activities along with a given transaction and, second, to the fewness of the transfers made by the diversified firms Davidson observed. The fewer the transfers a firm expects to make the greater will be its reliance on licensing. Whether this limited transfer activity is a characteristic in its own right or merely reflective of omitted characteristics (industry, product complexity etc.) is a question which can not be resolved with the data as presented.

If it is the case that the cost of making contingent arrangements is lower the older and more widely known is a technology, then the likelihood of market transfer should increase with the age of a technology and should be greater for imitations than for innovations. A naive inspection of Davidson's tables reveals that: (a) reliance on licensing increases initially with the age of a technological innovation; (b) reliance on licensing does not change with the age of imitations; (c) imitations are not, on average, licensed more than innovations (p. 139).

Only finding (a) is consistent with expectations. Even here, reliance upon licensing does not increase continuously with age. A more rigorous examination of this important relationship is

reported in Section 5.4.7. This increase in rigor does not, unfortunately, extend to a full specification of the model and we must be content with this rather weak evidence.

The complexity of a technology may be reflected in part in the R & D intensity of its developer. In this case the technologies developed by R & D intensive firms are more likely to be transferred internally. Davidson finds that this is indeed the case. As R & D intensity rises the fraction of transfers of technologies of a given age by license falls (p. 143). As we will demonstrate in Section 5.4.7 this relationship prevails for both innovations and imitations.

5.4.7 Vernon and Davidson (1979)

This study presents a series of cross tabulations designed to illustrate the characteristics of 406 new product transfers and 548 transfers of imitations undertaken by 57 U.S. based multinationals during the period 1946-75. The same data are presented in a different form and are subject to a more detailed scrutiny in Davidson (1979).

The data presented by Vernon and Davidson allow the reader to distinguish between technologies transferred to affiliates and to independent licensees on a characteristic-by-characteristic rather than a multiple characteristic basis. A number of differences in characteristics were reported in Section 5.4.6 of this study. A number of others do not bear directly on the hypotheses being tested here. These include findings that: (a) the likelihood that a transfer will occur via license has fallen over time

(p. 63); (b) the likelihood that a transfer will occur via license is independent of the size of the transferor (p. 71); (c) the likelihood that a transfer will occur via license is independent of the proportion of the transferor's sales from foreign sources at the time of U.S. introduction of the technology (p. 73).

Vernon and Davidson also find that the probability that a transfer will occur via license is lower the greater is the number of foreign affiliates of the transferor (p. 75). This is consistent with the proposition that the marginal cost of an internal transfer is less than its average cost so that internal transfer appears relatively more attractive given the existence of an affiliate.

The cross tabulations Vernon and Davidson report are sufficient to support a more rigorous examination of the relationship between the probability of internal transfer, the age of the technology, the R & D intensity of the transferor (product complexity) and whether the technology is an innovation or an imitation.

The discussion in Section 3 implies that the probability of internal transfer will increase with the complexity of the technology (transferor R & D intensity), decrease with the age of the technology and be greater for innovations than for imitations. In addition one expects that the marginal effect of complexity decreases with age and that the marginal effect of age increases with complexity. This would imply an age-complexity interaction term with a positive sign. Finally, the marginal effect of both age and complexity will be smaller in the case of imitations. This implies another series of interaction terms.

The grouped data reported by Vernon and Davidson will not support the estimation of the full range of interaction terms discussed above. The regression reported here allows the effect of age to differ between innovations and imitations and no more. The model can be written as

$$PI_i = a_0 + a_1 R_i + a_2 AM_i + a_3 AN_i + a_4 (AN_i)^2 + e_i \qquad 5.4.7.1$$

where PI_i = the fraction of transfers in the $i^{\underline{th}}$ R & D intensity-age-innovation/imitation cell which are internal (Tables 27 and A-18, Vernon and Davidson (1979)),

R_i = cell R & D intensity

AM_i = cell age of imitation at transfer

AN_i = cell age of innovation at transfer .

The use of grouped data together with a dependent variable which is truncated at both zero and one results in heteroskedastic residuals. This, in turn, biases the estimates of the standard errors of the a_i and thus the t-ratios upon which hypothesis tests are based. To eliminate heteroskedasticity the dependent variable is transformed and all variables are weighted. The dependent variable becomes

$$y_i = \ln[PI_i/(1-PI_i)]\ n_i(PI_i)(1-PI_i) \qquad 5.4.7.2$$

where n_i = the number of observations in the $i^{\underline{th}}$ cell.

All independent variables are weighted by the value

$$n_i(1-PI_i)(PI_i) \ . \qquad 5.4.7.3$$

Estimation of the model yields

$$y_i = 1.81 + \underset{(4.98)}{18.02R_i} + \underset{(.014)}{.019AM_i} - \underset{(.043)}{.063AN_i} + \underset{(.0006)}{.0009(AN_i)^2} \qquad 5.4.7.4$$

$$\bar{R}^2 = .55 \quad F(4,25) = 9.79 .$$

The results imply that internal transfer is more likely the higher is the R & D intensity of the transferor and less likely, to a point, the older is an innovation (the negative linear term, AN, dominates the squared term for technologies under thirty years of age subject to a wide confidence interval). The age of an imitation does not affect its mode of transfer.

These results provide some support to the basic proposition that market transfer is more likely the older and the less complex the technology. A fully specified model may confirm or contradict the inferences drawn above. Moreover the grouping of the data discards the considerable information provided by intra-cell variation. A model which employed ungrouped data and thus faced the full range of variation among transfers might support yet another set of inferences.

6. Policy Implications

6.1 Introduction

A number of groups have proposed policies which, in their view, would improve the terms upon which Canadians purchase technology from the rest of the world. These measures often involve the prohibition of some modes of technology transfer and of some facets of other modes.

Our empirical work has indicated that the type of prohibitions advocated would increase the cost of technology transfer. In Section 6.2 we present a model which analyzes the effect of an increase in the cost of technology transfer in terms of the existence of Canadian production. In Section 6.3 we present a model which analyzes the effect of increases in the cost of technology transfer in terms of the timing of the initiation of Canadian production.

In Section 6.4 we present a specific set of policy proposals, those of the Science Council of Canada. We predict their effect on the cost of technology transfer and thus on the timing of the initiation of Canadian production and on the wealth of the transacting parties.

6.2 The Incentive to Exploit New Technologies in Canada

Whether a new technology will be exploited in Canada depends on cost and demand conditions in Canada relative to alternative sources of supply and on the cost of transferring the technology. In this section we employ a simple model, suggested by Spence (1977),

to illustrate the effect of market size, tariff levels, the shape of the long-run cost function and the cost of technology transfer on the decision to produce in Canada.

Let x be the number of units of output produced in the U.S. for the U.S. market. Let the Canadian market be $1/k^{\underline{th}}$ the size of the U.S. market. Finally, let the ad valorem tariff rate set by Canada on U.S. products be τ percent. If the U.S. unit cost function is

$$A(x) = a + bx^{-1} \qquad 6.1.1$$

the Canadian unit cost function will be

$$C(x) = a + kbx^{-1} \qquad 6.1.2$$

Canadian and U.S. unit costs will diverge more markedly the smaller is the U.S. market size. Given a Canadian tariff of τ percent, the landed price of the U.S. product is

$$(1+\tau)\ A(x) = (1+\tau)\ (a+bx^{-1}) \qquad 6.1.3$$

Since the absolute difference between U.S. and Canadian unit cost is a decreasing function of U.S. market size ($b(k-1)x^{-1}$), there will be some U.S. market size x^* at which Canadian unit costs are just equal to the landed price of U.S. goods. That is

$$x^* = -[b((1+\tau) - k)]/a\tau \qquad 6.1.4$$

If U.S. market size exceeds x^* production will occur in Canada. If U.S. market size is less than x^*, Canada will be supplied by imports. It is easily shown that $\delta x^*/\delta\tau$ is less than

zero. That is, the higher is the Canadian tariff the smaller is the U.S. market size at which Canadian production begins to occur. Similarly $\delta x^*/\delta k$ is greater than zero. The smaller is the Canadian market as a fraction of the U.S., the larger is the U.S. market size at which production begins to occur.

The analysis to this point has assumed that when production begins in Canada, it does so with the same total cost function, being burdened only with a smaller market size to spread fixed cost, b, over. The implication is that whatever knowledge is required to begin production in Canada is available at the same price as is paid in the U.S. Suppose it is not. Suppose Canadians take measures that make it more costly to transfer the relevant technology to Canada than within the U.S.

One way of looking at such a change is to assume that it increases fixed cost in Canada (b_c) above fixed cost in the U.S. (b_u). In this case x^* becomes

$$x^* = -[b_u(1+\tau) - kb_c]/at \qquad 6.1.5$$

Since $\delta x^*/\delta b_c$ exceeds zero, the greater this increase in fixed cost in Canada relative to the U.S., the greater is the U.S. market size necessary before production begins in Canada. Quite simply, measures which increase the cost of transferring technology into Canada decrease the likelihood that, for any given environment, production will occur in Canada.

It can also be shown that $\delta^2 x^*/\delta\tau\delta b_c$ is less than zero. The greater is fixed cost in Canada relative to the U.S., the greater is the effect of a tariff reduction on the market size necessary

for Canadian output to exist. By increasing the cost of importing technology at the same time as it reduces tariffs, the government of Canada is increasing the impact of tariff reductions on the location decision.

If the relative advantage to Canadian production is given, as is the cost of technology transfer, then the only response to measures which increase the cost of transacting is to eliminate the marginal transfer. The volume of transactions in technology is reduced.

If, however, the relative advantage to Canadian production is growing over time (x^* is growing) or the cost of technology transfer declines as the latter grows older (b_c is falling), the adjustment to measures which increase the cost of technology transfer will take a different form. There will be no reduction in technology transfer but there will be a delay. Increases in the cost of transacting in technology will result in the postponement of these transactions. In the following section we determine what type of transfers will be postponed and attempt to provide a framework within which the costs of postponement and their incidence can be assessed.

6.3 The Timing of Technology Transfer

In the previous section it was demonstrated that, given cost, demand and tariff conditions, there will be some domestic market size at which there is a net advantage to the location of production in Canada. In this section we present a model with which to analyze the effect of public policy on the timing of the initiation of

domestic production. Specifically, we analyze the effect of measures which change the cost of technology transfer on the timing of the transfer and thus on the speed with which new technologies are exploited in Canada.

The analysis proceeds from time T_0 at which the domestic market is such that there is a net advantage to Canadian production. We would not expect to observe Canadian production before T_0 simply because this would involve a reduction in surplus. As the previous section demonstrated, T_0 may never occur or it may occur many years after the initial introduction of the technology.

If the transfer of technology is not costless and previous sections have provided ample evidence that it is not, the initiation of Canadian production may be postponed beyond T_0. Consider the case in which the net advantage to Canadian production in period t is V_t such that

$$V_t = V_0 e^{-(r-g)t} \qquad 6.2.1$$

where r = the opportunity cost of one dollar's worth of resources

g = growth rate in the net advantage to Canadian production

$g < r$

and $t = 0$ at T_0 .

Postponement of the initiation of Canadian production from the beginning to the end of period t involves a loss in surplus of V_t (L in Figure 6.1).

The cost of transferring the technology to Canada for exploitation at the beginning of period t is

$$C_t = C_0 e^{-(r+m)t} \qquad 6.2.2$$

where m = the rate at which the cost of transfer declines over time.

The assumption of a decline in the cost of transfer is reflective of the reasoning and evidence advanced in previous sections. The older a technology the less costly it is to specify the contingencies associated with transactions in it. This will be true of both market and internal transactions. We have argued, however, that age will exert a relatively greater effect on the cost of market transfers.

The postponement of the transfer frees the resources which would have been allocated to this activity to earn a return r in some alternative activity. It also results in a reduction in the cost of transfer. The gain from a marginal postponement of the transfer at time t, as seen from T_0, is G^1 such that

$$G^1 = (r+m)C_0 e^{-(r+m)t} \qquad 6.2.3$$

Provided $(r+m)C_0 > V_0$ the transfer will be postponed, taking place at some $T_1 > T_0$. At T_1 the marginal gain from additional postponement is just equal to the marginal cost, in terms of surplus foregone, of doing so. That is, at T_1

$$V_0 e^{-(r-g)t} = (r+m)C_0 e^{-(r+m)t} \qquad 6.2.4$$

$$\text{or} \quad T_1 = [\ln(r+m) + \ln C_0 - \ln V_0]/(m+g) \qquad 6.2.5$$

The solution for the surplus maximizing transfer date is illustrated in Figure 6.1. It has the following characteristics.

First, if the cost of technology transfer is sufficiently low, $(r+m)C_0 < V_0$, domestic production begins at T_0, that is, as soon as there is a net advantage to it. Second, the cost of technology transfer may be such that domestic production does not begin as soon as its advantage over foreign supply appears. Third, there are two reasons in this model why domestic production ultimately occurs. Either is sufficient to guarantee that at some point the technology will be transferred to Canada. The first assumption is that the net advantage to Canadian production is growing over time. The second is that the cost of the transfer is falling over time. Absent both of these assumptions and transfer will be postponed indefinitely. Finally, the lag between the emergence of a surplus to Canadian production and the emergence of Canadian production, $T_1 - T_0$, is: (a) greater the greater is the cost of technology transfer, $\delta T_1/\delta C_0 > 0$; (b) greater the smaller is the net advantage to Canadian production, $\delta T_1/\delta V_0 < 0$; (c) greater the smaller is the rate of growth in the net advantage to Canadian production, $\delta T_1/\delta g < 0$; (d) greater the greater is the rate of discount, $\delta T_1/\delta r > 0$. The effect on T_1 of a change in the rate at which the cost of technology transfer declines over time is ambiguous, $\delta T_1/\delta m \gtrless 0$.

This model may be extended to deal with a number of other cases which the reader might consider more representative of the Canadian situation. First, the advantage to Canadian production may be declining rather than increasing over time. This might occur if the owner of the technology has the option of supplying Canada from some third country. The technology will still be

transferred to Canada, albeit later, provided /m/>/g/.

Second, the net advantage to Canadian production as seen by the technology owner, V_0, may be less than the total net advantage. Workers employed in domestic production may be paid wages in excess of their opportunity cost. These rents should be included in the net surplus resulting from Canadian production. Similarly, to the extent that the domestic skills and knowledge necessary to exploit the technology are not obtained at opportunity cost, that is, that there are mutual gains from trade, the surplus resulting from Canadian production exceeds V_0. In cases such as these the optimal transfer date will precede that which is chosen. This is illustrated in Figure 6.1 as T_2. The loss resulting from the postponement of transfer is given by the shaded area. Depending on the source of the divergence between V_0 and S_0, this may be a loss only in the "Nirvana" sense of the word. That is, it may represent surplus that would have accrued to the transacting parties had their transaction been "ideal".

We turn now to the analysis of the effect of government policies toward technology transfer. Consider the effect of a restriction which increases the cost of technology transfer. The effect of such a restriction is to shift up the G^1 function and further postpone the transfer. This is illustrated in Figure 6.2. The transfer is postponed from T_1 to T_3. Surplus foregone due to this postponement is given by shaded areas A + B. Area B is the loss born by the foreign owner of the technology. Area A is the loss born by co-operating Canadian factors. The requirement that a more costly mode of technology transfer be used also reduces the

FIGURE 6.1

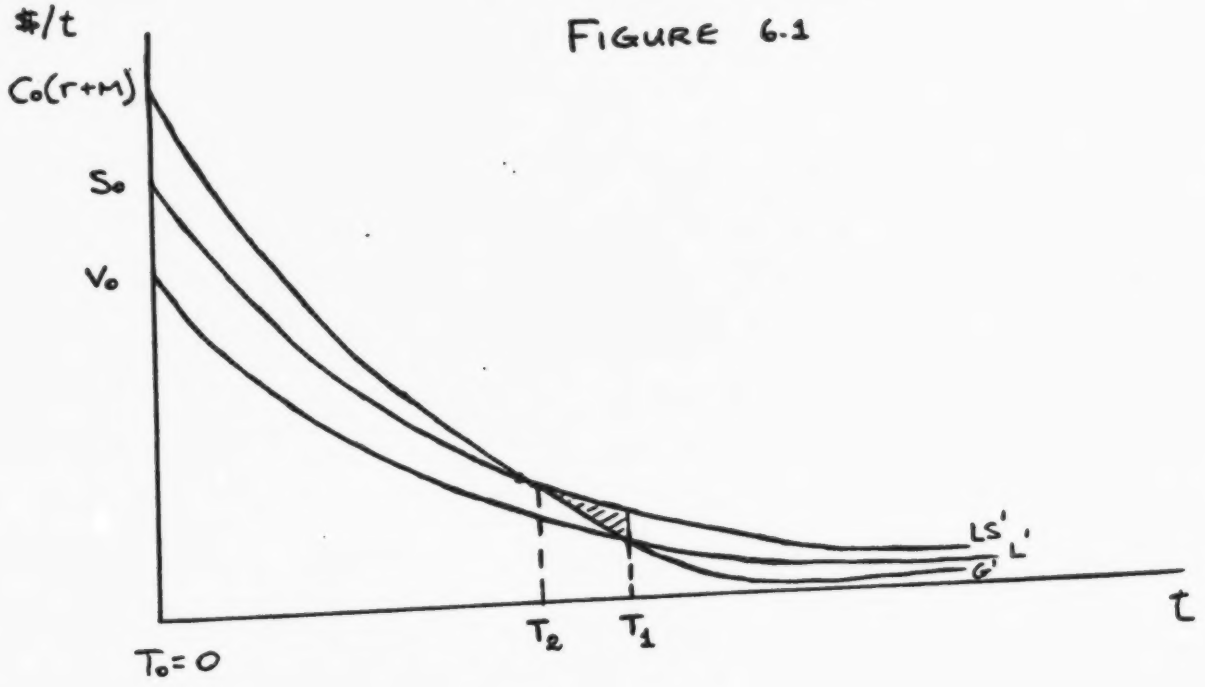
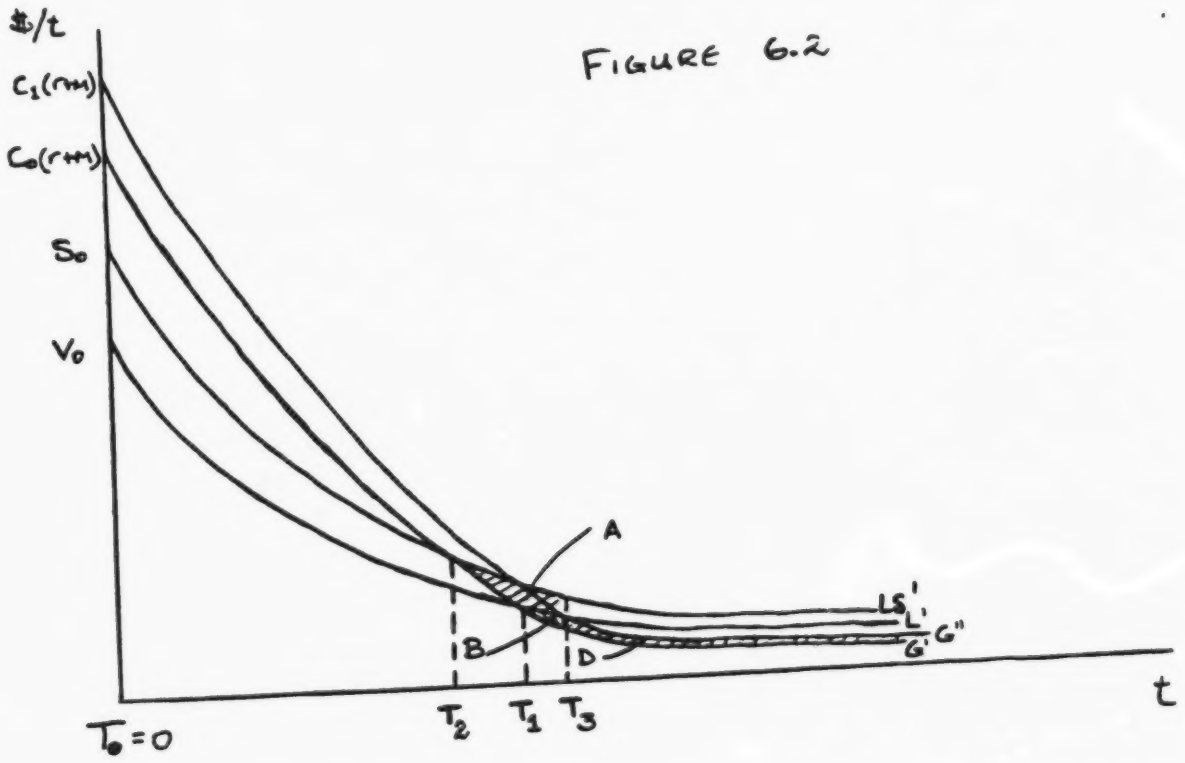


FIGURE 6.2



total surplus generated once it does occur. This reduction in surplus can be represented by area D. The fraction of this loss in surplus born by Canadian factors is $(1-V_0/S_0)$.

The important conclusion to be drawn from this analysis is that measures which increase the cost of transferring technology to Canada will result in a postponement of such transfers with a consequent loss of surplus which is generally born by both the foreign owner of the technology and the Canadian owners of the knowledge, skills and experience necessary for its local exploitation.

6.4 Public Policy and the Cost of Technology Transfer: The Effect of the Adoption of the Proposals of the Science Council

A research report issued under the auspices of the Science Council of Canada has recently recommended that the mandate of the Foreign Investment Review Agency be altered to enable that agency to regulate imports of technology (Britton and Gilmour, 1978). While the Science Council has yet to take an official position on this recommendation, there can be little doubt that the report is reflective of the Council's views (Globerman (1978)).

Science Council recommendations are not binding on the government of Canada. They can, however, influence the government's legislative program. For this reason it is worthwhile to examine the type of regulation advocated by the Council and to discuss both the manner in which it might be applied and its ultimate effect.

At present the Foreign Investment Review Agency regulates both the acquisition by foreigners of businesses currently operating in Canada and the initiation by foreigners of new Canadian businesses. The Science Council study advocates that FIRA be authorized to regulate "New licensing and franchising agreements and joint ventures involving an enterprise already in Canada (foreign or domestic) and a business enterprise entering Canada for the first time" (Britton and Gilmour, p. 188).

Were FIRA to be granted this additional authority, only technology transfers which are carried out within established transnational firms and are related to their existing lines of business will escape government scrutiny.

The Council study advocates that this expanded power be used by FIRA, first, to close some industries altogether to foreign direct investment and, in all cases, to discourage foreign direct investment in favour of licensing and joint ventures. Internal technology transfers are to be discouraged, arm's length transfers encouraged.

> "For certain designated industries, at certain times, licensing agreements and joint ventures will be the only permissible way of obtaining foreign technology: but even for 'unprotected industries' these methods are to be preferred over technology and purchasing associated with foreign direct investment" (p. 190)

Second, it is argued that the power to prohibit the importation of technology should be used by FIRA to alter the terms of trade in favour of Canadian parties to technology transfers. Having prohibited the internal transfer, FIRA proceeds to function

as the sole agent for arm's length transfers. This enables it to negotiate better terms for its Canadian clients.

> "This will involve the agency in bargaining with potential investors and/or sellers of technology as well as potential technology purchasers, and, at times seeking (1) alternative sources of technology amenable to transfer through a license agreement or a joint venture, and (2) suitable Canadian licensees and participants for joint ventures. This implies the agency should become a much more active intermediary in the process of transferring foreign technology to Canada than FIRA is at present" (p. 191)

Finally, the Council study contends that, while FIRA need not participate in the negotiation of all arm's length technology transfers, it should scrutinize their terms with a view to eliminating license provisions which, in its opinion, are not beneficial to Canada.

> "It should also be a central function of the agency to review the terms of all arm's length agreements including those for which it was in part or wholly responsible. Licensing agreements and joint ventures may carry restraints similar to those associated with foreign direct investment, e.g. tied procurement and export restrictions. Contractual techniques can lead to a licensee being effectively controlled by a licensor. All agreements should be reviewed by the agency with a view to improving the contractual terms for Canada" (p. 192)

The essence of the Science Council's approach, then, is one of discouragement if not outright prohibition of foreign direct investment, state participation in and occasional control of the negotiation of technology transfer arrangements and state scrutiny of the provisions of transfer agreements with the possible prohibition of certain licensing practices.

The manner in which an augmented FIRA might actually carry out this mandate can be inferred, first, from its present operation and, second, from the Council's views on the source of Canada's industrial problems.

The Foreign Investment Review Agency presently approves 81 per cent of applications to acquire existing Canadian businesses and 85 per cent of applications to establish new businesses. Applications which are approved often involve commitments by the applicant to create a number of "new" jobs, to buy inputs from Canadian sources, to export a certain fraction of output and to undertake a certain amount of research in Canada. The assumption is the FIRA's intervention has created new and desirable kinds of economic activity in Canada.

An example of this type of intervention is provided by the application of British retailer Marks and Spencer to acquire the Canadian chain operated by Peoples Department Stores. Approval of the application ultimately involved the commitment by Marks and Spencer to: (1) an investment of $1 million in three new stores in 1977 and an additional $3 million for twelve new stores by 1980; (2) eighty-three new jobs for Canadians in new stores to be opened in 1977; (3) obtaining from Canadian suppliers at least 70 per cent of St. Michael textiles and clothing and at least 40 per cent of St. Michael foodstuffs; (4) using Marks and Spencer textile technology and industrial management expertise in the development of Canadian-made St. Michael merchandise; (5) spending at least $100,000 annually through 1980 on Canadian research and development in textile and clothing technology; (6) promoting the

export of Canadian made St. Michael products; (7) ensuring that a Canadian is elected and maintained on Marks and Spencer's board of directors in Britain (Byron (1978), p. 6).

That the Science Council would have similar requirements imposed upon those proposing to transfer technology to Canada can be inferred from its perception of the problems of Canadian industry. It concludes that the excess of Canadian imports over exports of high technology products is "too great", that high skill jobs occupy a disproportionately small fraction of the Canadian labour force and that Canada's indigenous technological capability is insufficient (Britton and Gilmour, Ch. 2-4).

The Council study alleges that this state of affairs is due, first, to the confinement by foreign multinationals of their Canadian units to current technologies and to the Canadian market and, second, to stipulations in technology transfer agreements which have the same effect (Britton and Gilmour, Ch. 5).

A number of commentators have noted that there is no evidence to support these conclusions (Palda (1979), Daly (1979), Safarian (1979)). The quality of Science Council study is not at issue here. For present purposes it is sufficient to note that the conclusions reached in the study support a policy of: (1) further restrictions on foreign direct investment; (2) the continuation, if not a more zealous pursuit of the present policy of requiring direct investments which are approved to meet government goals in exports, the hiring of Canadian scientists and engineers, the conduct of research and development in Canada and the sourcing of inputs in Canada; (3) the prohibition of provisions of arm's length

technology transfers which appear, to government, to have the effect of reducing Canadian exports, research or the sourcing of inputs in Canada.

The features of technology transfer agreements most likely to meet with the disapproval of FIRA are: (1) export restrictions; (2) tie-ins; (3) tie-outs and package licensing and; (4) grantbacks. These provisions would, in the view of the Science Council, restrict the ability of Canadian producers to export high technology products, to conduct the full range of production activities in Canada, to shop around for the appropriate combination of technologies and to use foreign technology as a foundation for an autonomous technological capability.

Let us consider first the proposal to eliminate altogether foreign direct investment in some fields. This is the same as eliminating the possibility of internal transfers of technology. In cases where the market mode of transfer would have been chosen in any case such a restriction will have no effect. In cases where internal transfer would have been chosen, the restriction will require the adoption of the more costly market mode. The effect of this increase in the cost of transfer was illustrated in Figure 6.2. The transfer is postponed and potential surplus is foregone. Unless all Canadian factors have been reduced to their opportunity cost, this loss of surplus will be born jointly by foreigners and Canadians.

Consider second the proposal to impose conditions upon those wishing to make internal transfers. In the Marks and Spencer case the commitments extracted by FIRA may have represented activities

Marks and Spencer would have undertaken in any case. In this case the conditions imposed on the new entrant are mere cosmetics.

Alternatively, these commitments may have represented activities Marks and Spencer would not otherwise have undertaken. In this case the conditions imposed by FIRA must be surplus reducing. This reduction in surplus may be the result of a wasteful use of resources, that is, the allocation of resources to activities in which they do not earn their opportunity cost. The reduction in surplus may also be the result of a transfer to co-operating Canadian factors. In either case the effect of these restrictions is to reduce the demand price for the Canadian assets being acquired. There is either a waste of resources or a transfer to a third group, the cost of which is born jointly by Marks and Spencer and the owners of the Canadian assets being acquired.

Within the context of a foreign investment designed to effect an internal technology transfer, the imposition of resource using conditions by FIRA simply shifts the cost of technology transfer upward. This was illustrated in Figure 6.2 and discussed above. Transfer is postponed, surplus is foregone and both foreign and domestic wealth is reduced.

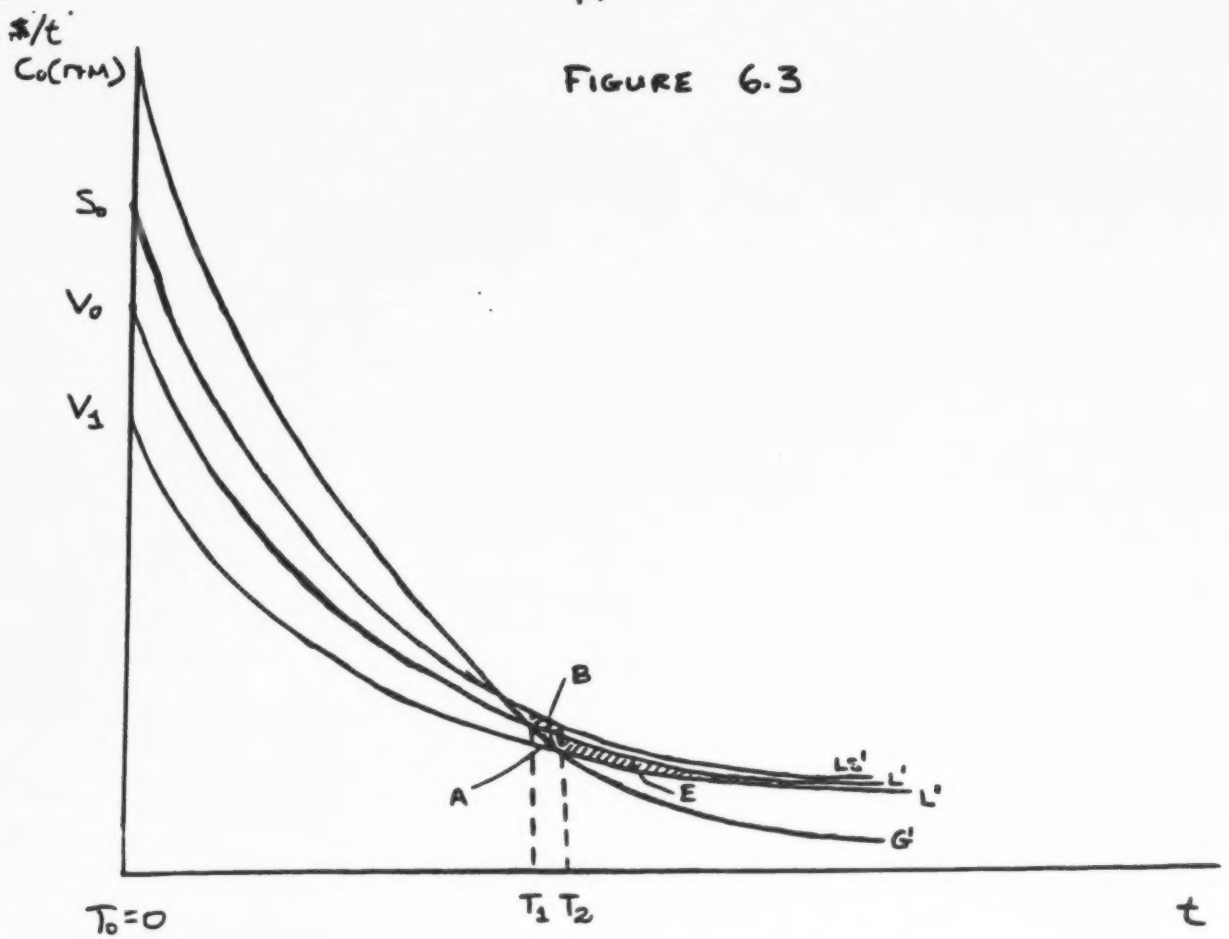
If the conditions imposed by FIRA simply transfer a greater fraction of the gains from trade to Canadians, our conclusions are somewhat different. It is difficult to conceive of conditions which would entail only a transfer. Certainly those presently imposed by FIRA have a relatively large resource-using component. If such a wealth transfer were required as a condition of exploitation of a technology in Canada the result could be illustrated

in several ways. The simplest is simply to shift the technology owner's net income function, $V_0e^{-(r-g)t}$, downward. This is illustrated in Figure 6.3. The result is that Canadian exploitation is postponed until T_2. There is a loss of surplus on Canadian production which is born jointly by foreigners and Canadians. There is also a redistribution of surplus once the transfer has been made (area E). Domestic factors experience a net gain of E-B. Foreigners experience a net loss of E+A.

Finally we consider the effect of restrictions on the nature of arm's length (market) transfers of technology. These include the prohibition of export restrictions, tie-ins, tie-outs and grantbacks which the Science Council has advocated. The prohibition of unilateral grantbacks has also been advocated by the authors of the Working Paper on Patent Law Revision (1976, p. 278). Finnegan (1978) reports that the less developed countries, as a group, would prohibit these and other clauses.

It was noted in Section 4 that the presence of such clauses in licensing agreements is neither necessary nor sufficient to imply that the gains from trade accrue disproportionately to one party. Indeed these clauses usefully be viewed as reducing the cost of licensing arrangements and thus increasing the gains from trade. Market restrictions and unilateral grantbacks allow the licensee a contractual method of renouncing markets for and uses of a technology for which he does not wish to pay. If such a renunciation is prohibited licenses will have to allow for the possibility of the licensee's use of the technology for purposes

FIGURE 6.3



and in markets in which he has no interest. As a consequence, the cost of the licensing arrangement is increased.

The tie-in is often employed as a measuring device to determine the intensity of use of a technology. It may involve lower costs than other methods of measuring intensity of use and will, therefore, increase the gain from trade. When compared with a situation in which intensity of use is not measured and price is set at some average of its value to all users, the tie-in clearly benefits the relatively small user of the technology. The prohibition of tie-ins can, therefore, be expected to increase the cost of the licensing arrangement without increasing the share of the now smaller gains from trade accruing to the Canadian licensee.

The tie-out is generally associated with a "best efforts" clause. It allows the licensee to stipulate that the licensed technology will be used rather than suppressed. The contractual commitment to use the technology allows the transacting parties to ignore the possibility that the technology is being licensed for purposes other than use and thus eliminates the necessity of negotiating terms to cover this. Again prohibition of the tie-in increases the cost of the transfer.

Prohibition of any or all of these licensing practices increases the cost of the licensing arrangement. The effect of this is illustrated in Figure 6.2. The cost function shifts upwards. Transfer is postponed. Surplus foregone totals A+B+D. The Canadian share of foregone surplus is $B + (1-(N_0/S_0))D$.

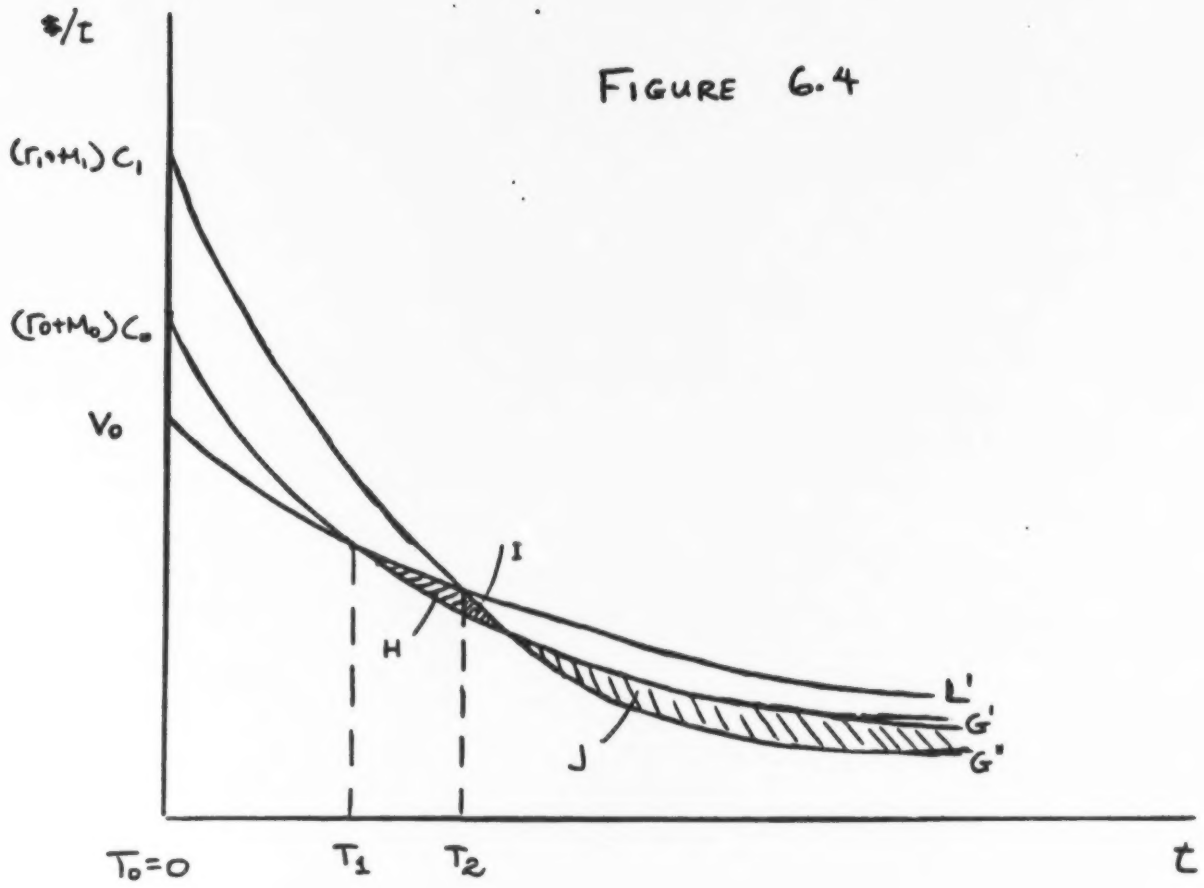
The foregoing has assumed that government restrictions on technology transfer have a relatively simple effect on transfer

costs. The prohibition of internal transfer, for example, leads to the adoption of the market mode which is assumed to be more costly at all points in time (see Figure 6.2). A principal feature of our theoretical argument was, however, that the cost of a market relative to an internal transaction will fall as the technology to be transferred grows older. While the cost of a market transaction may exceed that of an internal transaction initially, there will be some point in time at which the reverse becomes true. This changes our conclusions regarding the cost of measures which restrict internal transfer. To be specific, the cost of such measures is reduced.

As an illustration assume that the cost of a market transfer is $C_1 e^{-(r+m_1)t}$ and the cost of an internal transfer is $C_0 e^{-(r+m_0)t}$ where $C_1 > C_0$ and $m_1 > m_0$. The cost of a market transfer is higher initially but falls faster. The marginal gain from the postponement of the transfer is initially greater but ultimately less in the case of the market transfer. This is illustrated in Figure 6.4 in which the marginal cost, in terms of surplus foregone, of postponing the transfer is also plotted.

The adoption of the market mode would involve transfer at T_2. The technology is transferred later ($T_2 > T_1$) than is the case with the market mode and surplus given by area H is foregone. The cost of the market transaction exceeds that of the internal transaction by I - J. If the transacting parties choose the internal mode we must assume that H + I - J is positive. Prohibition of the internal transfer will, therefore, result in the reduction of surplus by

FIGURE 6.4



H + I - J. This loss must be less than that which occurs when the relative cost of the market transfer does not fall over time. That is, when comparing Figures 6.4 and 6.2, $(H + I - J) < (B + D)$.

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